much diminished, as it normally is on the upper side, and it is suggested that possibly there is an inverse physiological relation between the formation of guanin and the formation of pigment.

We conclude that exposure to light does actually cause the development of pigment in the form of normal chromatophores on the lower side of the Flounder, and also causes the absorption of the argenteum to a great extent. We infer, in spite of the occurrence of congenital abnormalities, that the exclusion of the light from the lower sides of Flat Fishes is the cause of the absence of pigment from that side in normal specimens. We think that the fact that the metamorphosis of the Flounder takes place at first normally, in spite of the light coming from below and being shut off from above, is, in respect of the pigmentation, in favour of the inheritance of acquired characters. When the exposure is continued long enough, the change that has taken place in consequence of heredity is reversed, and pigment appears.

We have discussed briefly the question of the physiological process of the formation of the pigment, but we have at present no decisive result to offer in this part of the subject, and need not include it in this abstract.

We consider that these investigations afford support to the view that the incidence of light is the reason why the upper and dorsal surface of animals is more strongly pigmented than the lower or ventral throughout the animal kingdom, and that the absence of light is the cause of the disappearance of pigment in many cave-inhabiting and subterranean animals.

III. "The Electric Organ of the Skate: Note on an Electric Centre in the Spinal Cord." By J. C. Ewart, M.D., Regius Professor of Natural History, University of Edinburgh. Communicated by Professor Sir W. Turner, F.R.S. Received March 15, 1893.

Having considered the development and structure of the electric organ of the Skate, it appeared to me desirable, by way of making my work more complete, to reinvestigate the nervous apparatus of the organ, and more especially to ascertain whether, as in *Torpedo* and *Gymnotus*, there is an electric centre. In *Torpedo* the electric organs are developed from a limited number of myotomes, and innervated by afferent fibres, belonging to a limited number of cranial nerves, which proceed from two large collections of cells—the electric lobes—situated in the region of the medulla. In *Gymnotus* the nerves for the electric organs proceed from two well-marked cellular tracts

which extend along the greater length of the spinal cord, one at each side of the central canal. In the case of the Skate the question at the outset is, granting the existence of an electric centre, is it, as in *Torpedo*, situated in the brain or, as in *Gymnotus*, in the spinal cord? Sanderson and Gotch* made out that in the Skate "a reflex centre is situated in the optic lobes," but, notwithstanding this, these lobes in the Skate in no way differ histologically from the corresponding structures in *Acanthias* and other Selachians unprovided with electrical organs.

The development of the Skate's organ from portions of the caudal myotomes, and its innervation by afferent fibres from certain caudal nerve, point to the electric centre being situated in the spinal cord rather than in the brain, and to its being, as in *Gymnotus*, on a level, and all but co-extensive, with the electric organ.

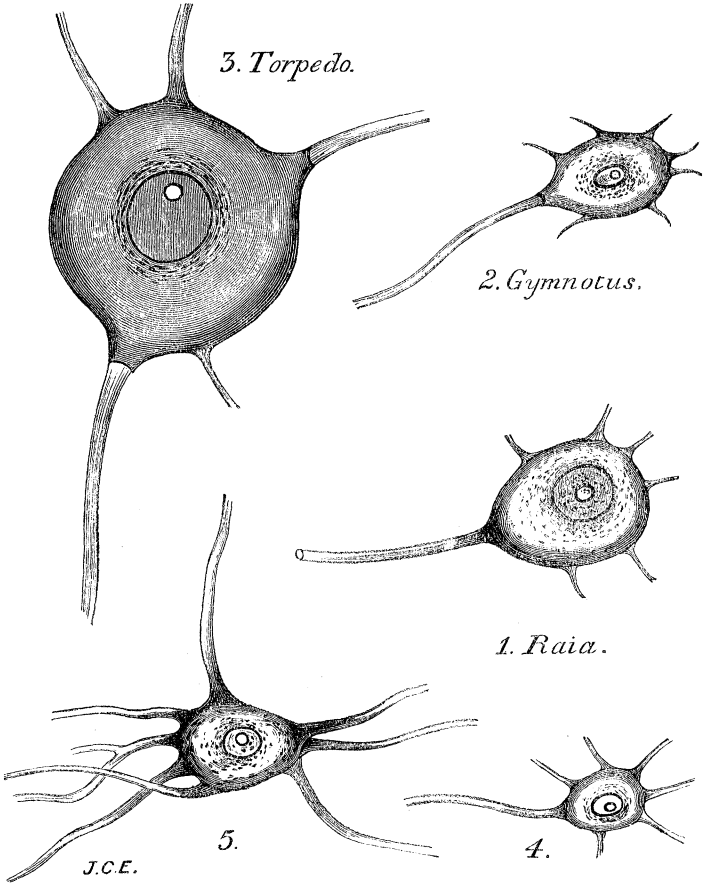
Having observed, when working at the development of the electric organ, a number of large nerve-cells in the caudal portion of the spinal cord, the sections of Skate embryos made some years ago were first examined. It soon became evident that in sections from the middle of the tail on a level with the electric organ certain cells of the anterior horn of the cord were very much larger than in sections through the root of the tail, and further that in late embryos and very young Skate there was an electric centre, resembling in many respects the electric centre in *Gymnotus*.

It did not, of course, follow that the electric nerve-cells persisted into adult life. They might degenerate, and thus the supposed feebleness of the Skate's organ might be accounted for. The fact that the Skate's organ increases in size as the fish grows larger led me, however, to expect that large nerve-cells would be found in the caudal region of the spinal cord in well-grown fish. In this I was not disappointed, for, though there was at first some difficulty in demonstrating the presence of electric nerve-cells in large fish, on obtaining perfectly fresh material their position, size, and relations were easily made out, and the remarkable difference in the appearance of sections of the cord at, and in front of, the root of the tail, from sections on a level with the electric organ, was at once evident. From the observations already made, it appears that the electric centre in the Skate closely resembles, from a morphological point of view at least, the electric centre in *Gymnotus*. The electric tract is, however, much shorter in the Skate than in the Electric Eel, and the cells are relatively fewer in number. On the other hand, the cells in the Skate are larger than in *Gymnotus*, and this is true not only of *Raia batis* but also of *R. radiata*, in which the organ is extremely small and poorly developed. Nerve-cells from the electric centres of *Torpedo*, *Gymnotus*, and *Raia* are represented in the accompanying

* 'Journal of Physiology,' vol. 10, N 4.

figures. Fig. 1 represents a cell from the electric centre of the Skate (a *R. batis* two feet in length); fig. 2 a cell from the electric centre of a well-grown *Gymnotus;* and fig. 3 a cell from the electric lobe of a large *Torpedo.* All three cells are camera drawings, and the same lenses were used in each case—objective D and ocular 2, Zeiss. It will be noted that, though the cell from the Skate is much smaller than the *Torpedo* cell, it is decidedly larger than the one from *Gymnotus.*

In sections of the Skate's cord on a level with the electric organ, small, as well as large, cells are usually visible in the anterior horn. The small cells are in connexion with the fibres which supply the untransformed caudal muscles. They agree exactly with the cells in the anterior horn throughout the entire length of the spinal cord lying in front of the electric organ region. One of these unenlarged



motor cells is represented in fig. 4. It was drawn from a section of the cord (of the same fish from which fig. 1 was taken), about six inches in front of the electric organ. It closely resembles, except in size, the electric cell (fig. 1), and it also resembles the large motor cells of the Mammalian cord. A motor cell from the spinal cord of a Mammal, drawn to the same scale as the other cells given, is represented in fig. 5.* This cell, smaller than the electric cell of the Skate (1), and still smaller than the cell from *Torpedo* (3), is about the same size as the electric cell of *Gymnotus* (2).

With the help of sections through a series of embryo Skate, for most of which I was indebted to Dr. Beard, I have been able to study the development of the cells in the Skate's electric centre. This part of the subject, together with the condition of the electric cells in large fish, will be dealt with in a subsequent communication. It may, however, be stated now: 1. That in *R. batis* embryos under 5 cm. in length none of the motor cells in the caudal region have undergone enlargement. 2. That in an embryo 5·8 cm. in length, although the muscular fibres seemed still unchanged, certain cells in the anterior horn of the caudal portion of the cord were distinctly larger than similarly shaped cells in their vicinity. 3. That in an embryo 15·5 cm. in length, in which the electrical elements were already well developed, the electric nerve-cells were large and conspicuous, so that sections through the cord in the region of the electric organ presented quite a different appearance from sections through the root of the tail, where no change had taken place in the cells of the anterior horn.

Presents, April 27, 1893.

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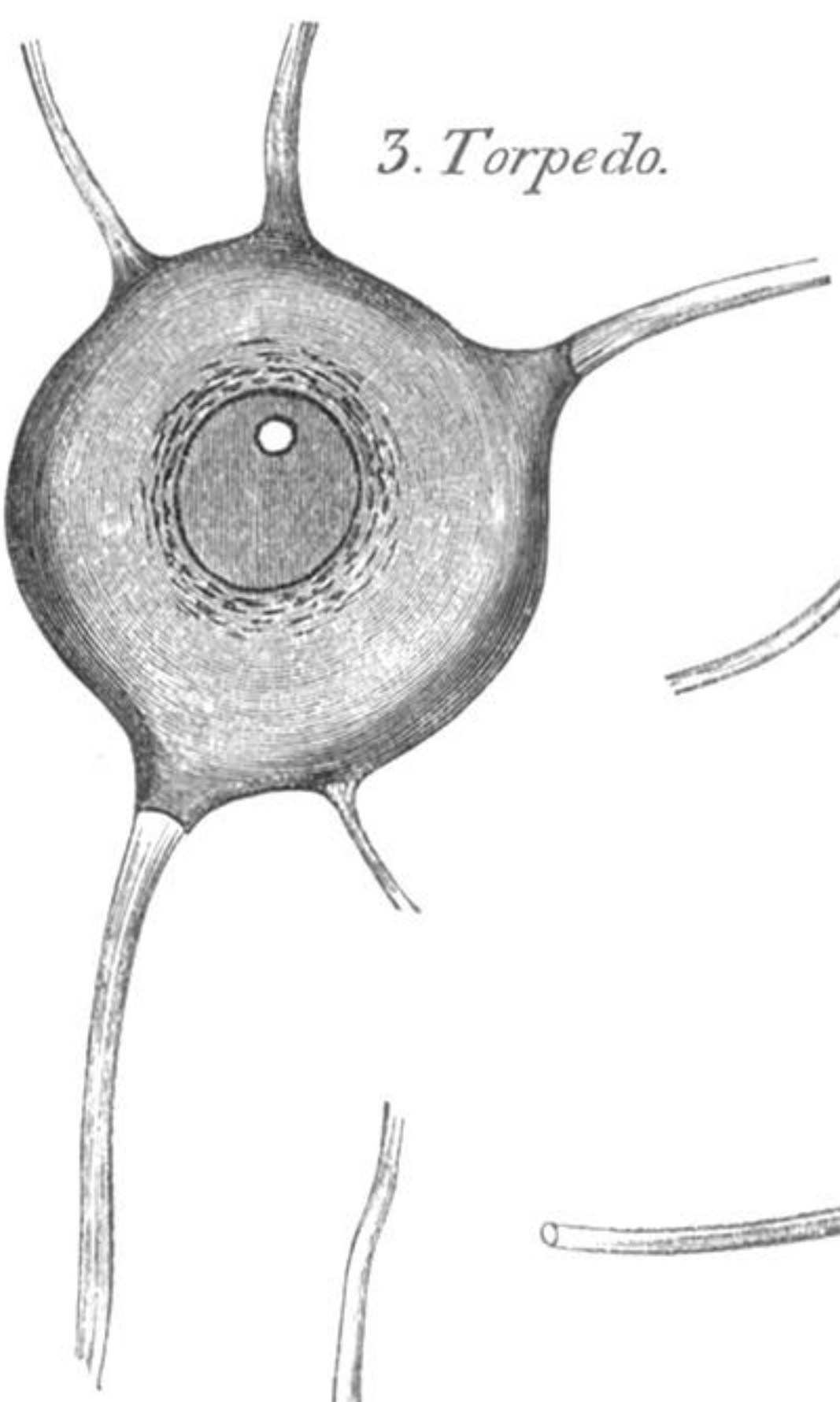
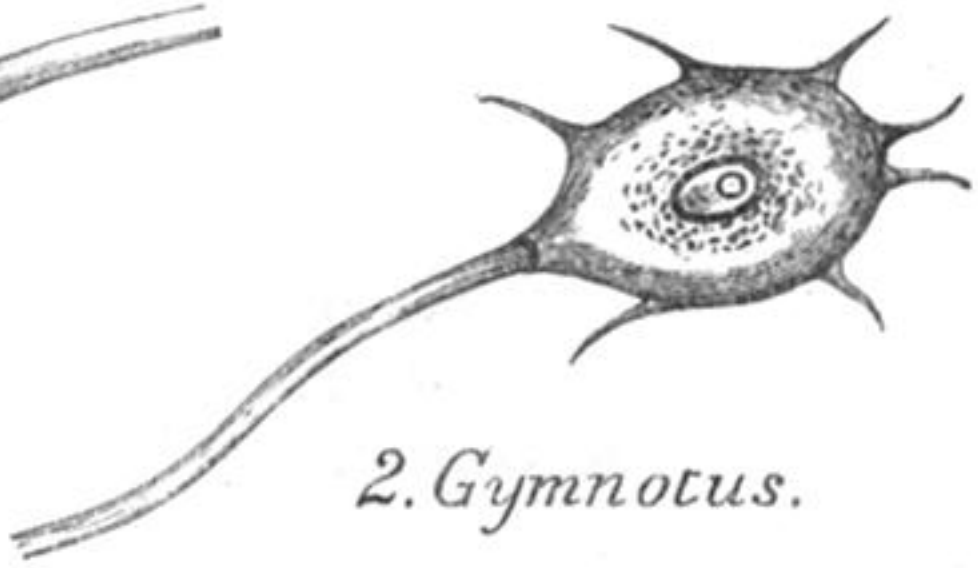
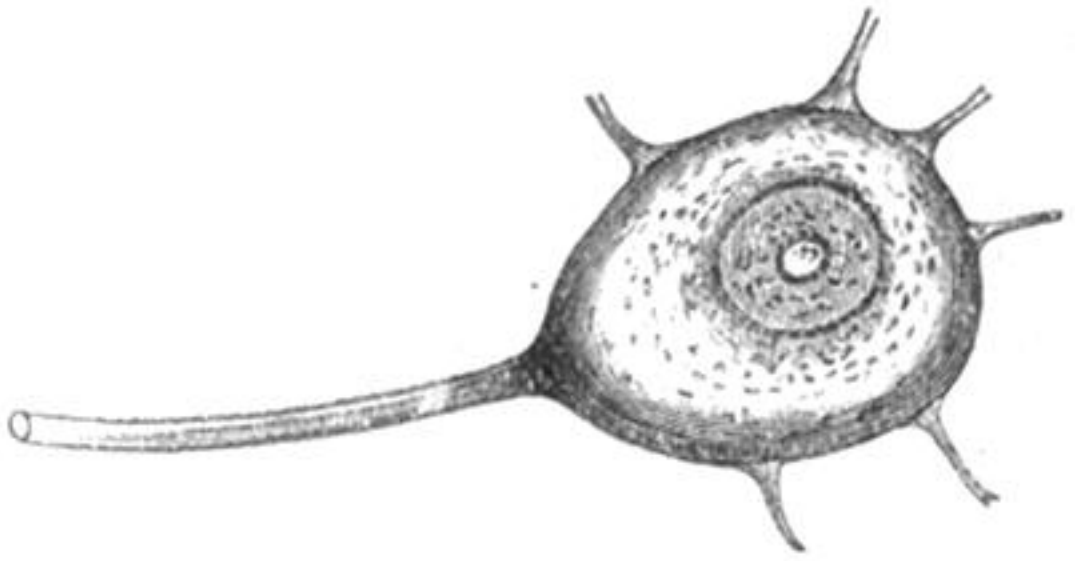
* For the use of the section from which fig. 5 was drawn I am indebted to Sir William Turner, F.R.S.



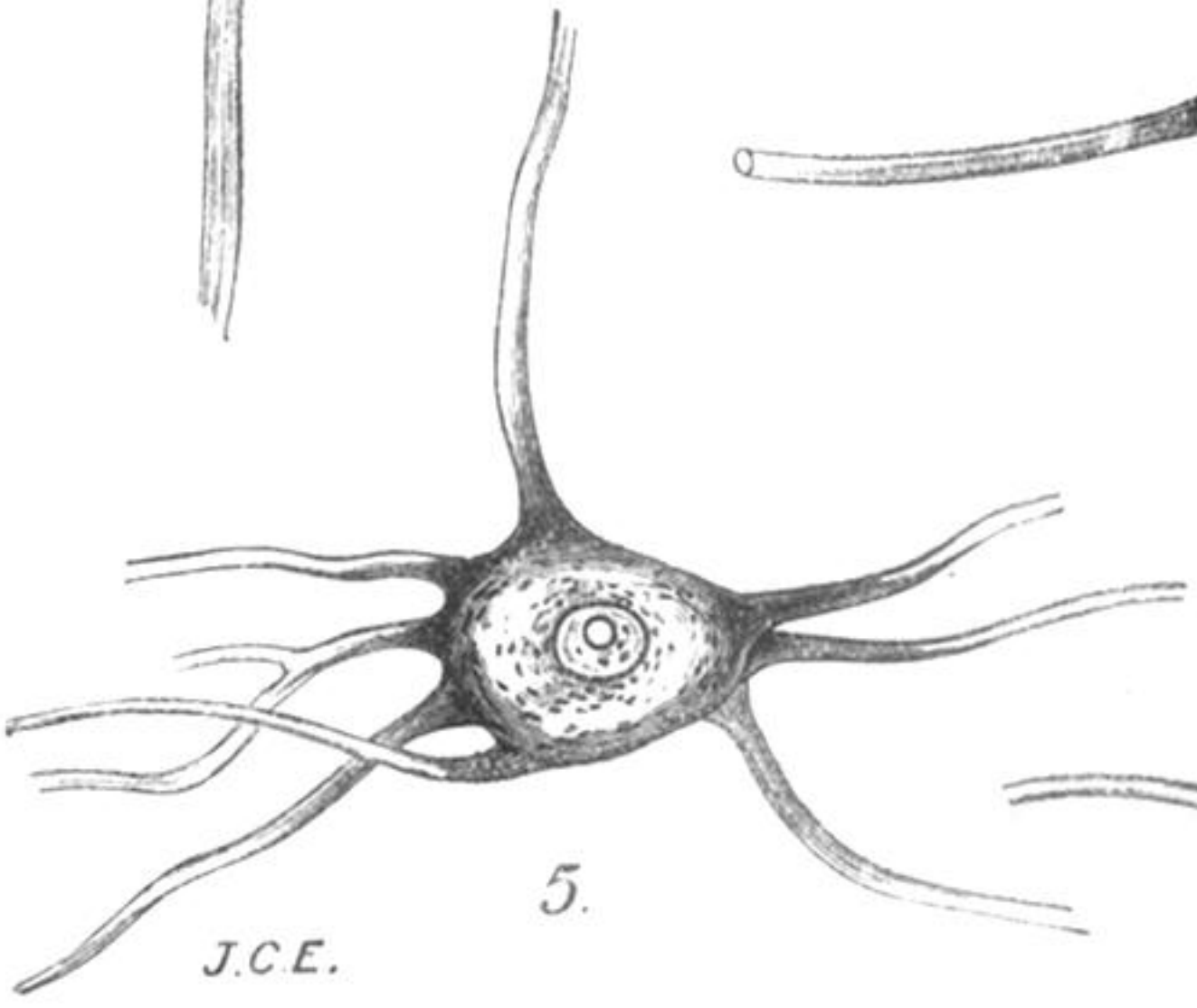
3. *Torpedo.*



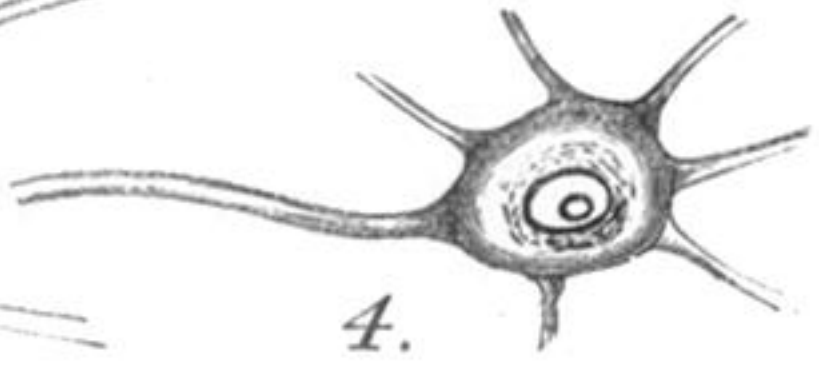
2. *Gymnotus.*



1. *Raia.*



5.



4.

J.C.E.